The Resource Prospector Near-Infrared Volatile Spectrometer System NIRVSS

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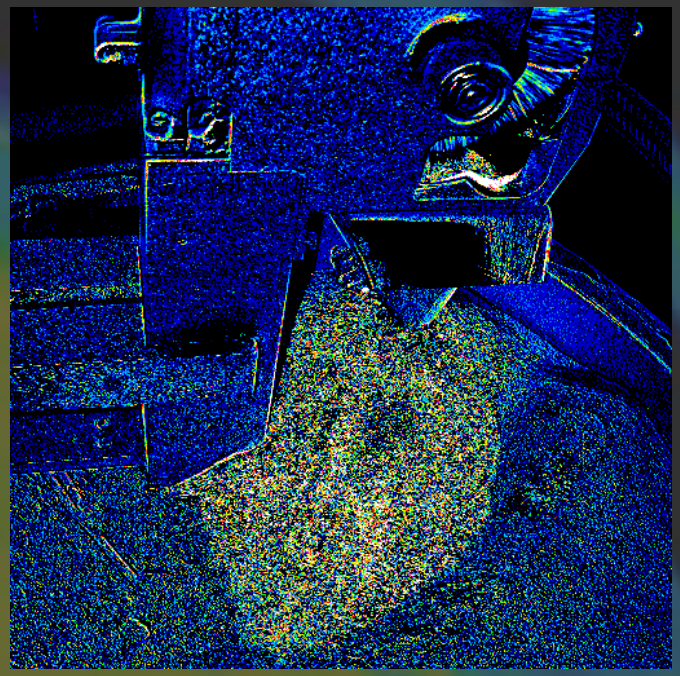
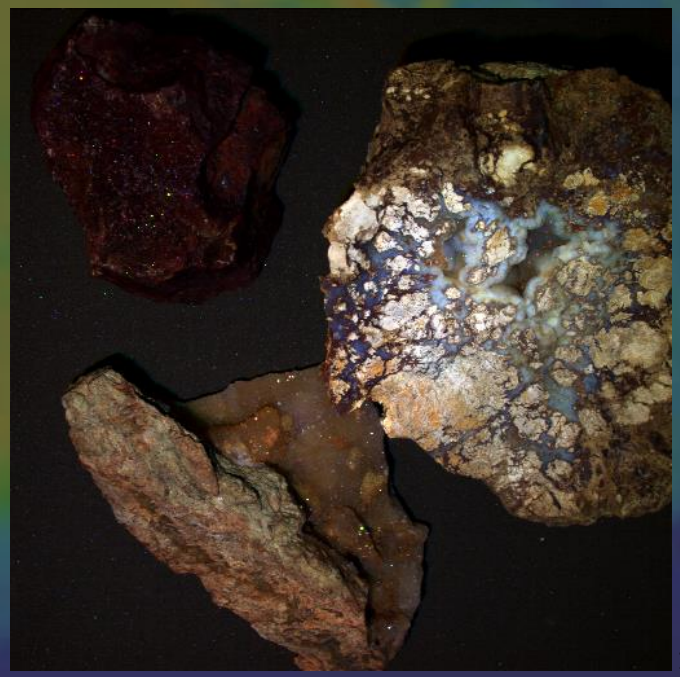
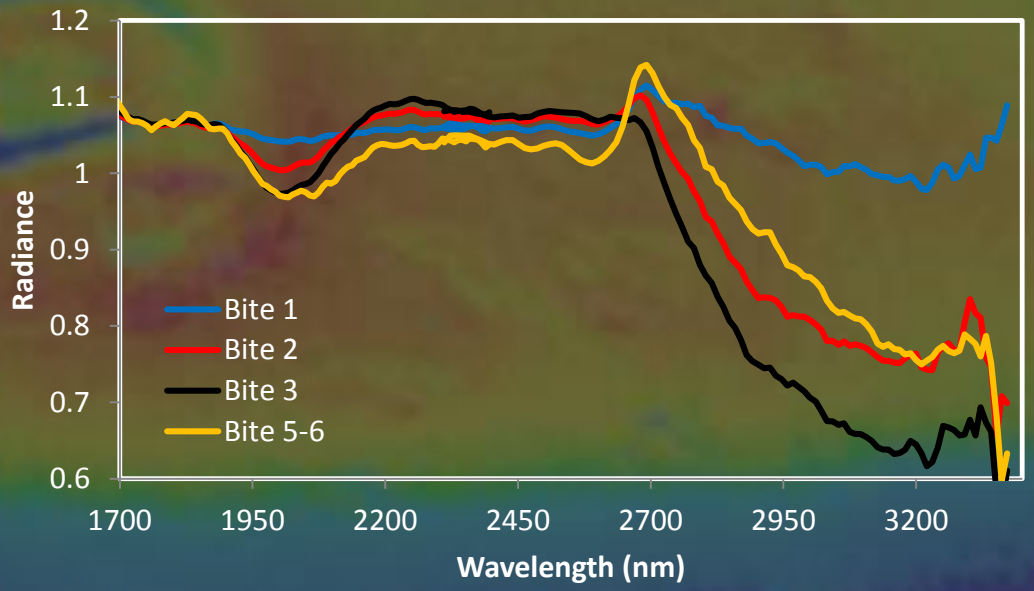


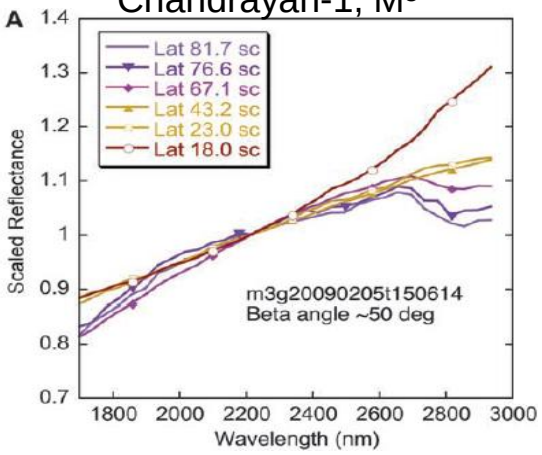




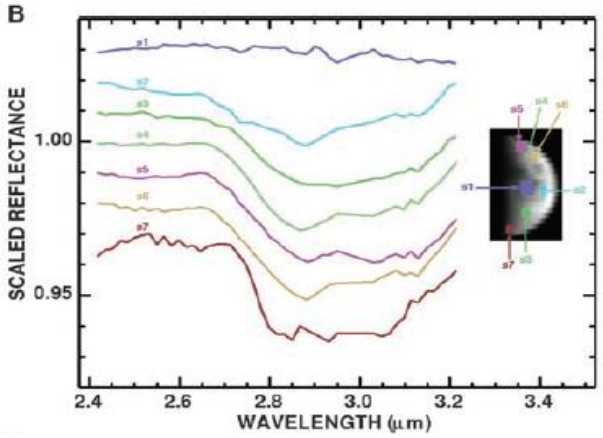
Why NIR Spectroscopy?

- Proven Technique
- Provides information on a range of solid volatiles, but also mineralogy
- Can provide additional information on the form (e.g., crystalline vs. amorphous ice) and grain size
- Instrumentation can have a relative small Project and Mission “foot print”, including low cost, mass, volume and power
- Can provide rapid evaluation of samples for cortical decision making

Chandrayan-1, M^3



Cassini, VIMS



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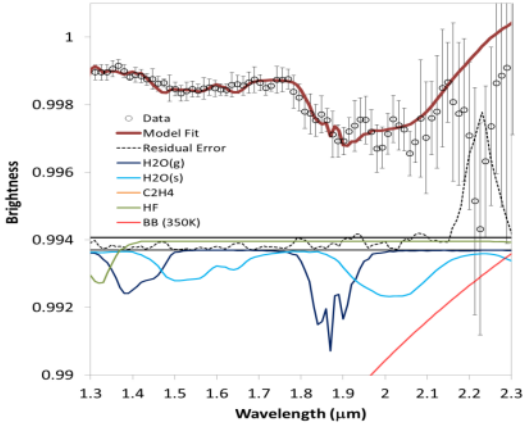
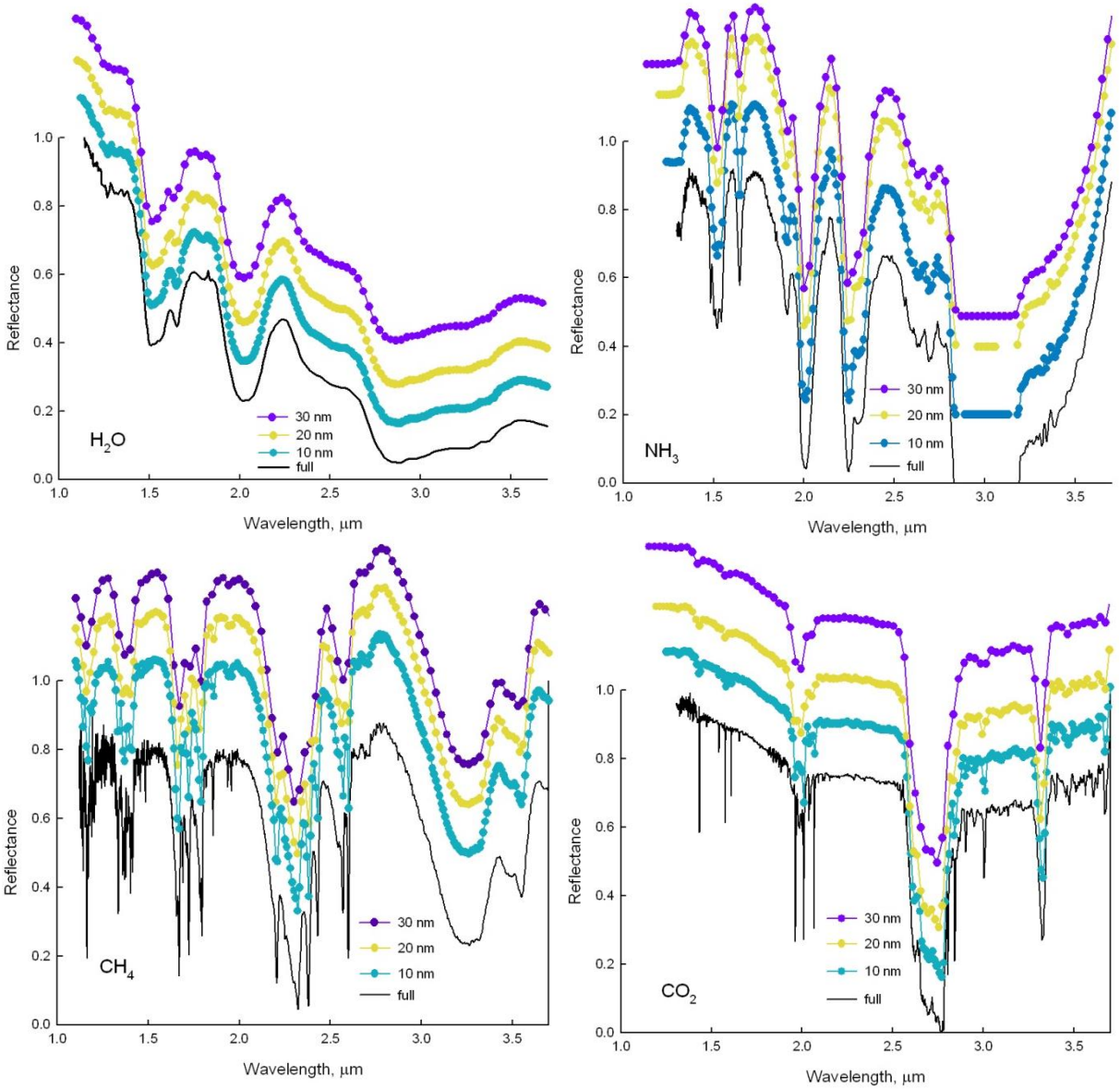


What Wavelengths and Resolutions?

Volatile search

- Species include: H_2O, NH_3, CO_2, CH_4
- Ample vibrational fundamental absorptions at near- to shortwave-infrared wavelengths (1.5-4 μm)
- Spectral resolution required:
  - H_2O: 20-30 nm
  - NH_3: 10-20 nm
  - CO_2: 10-20 nm
  - CH_4: 20-30 nm



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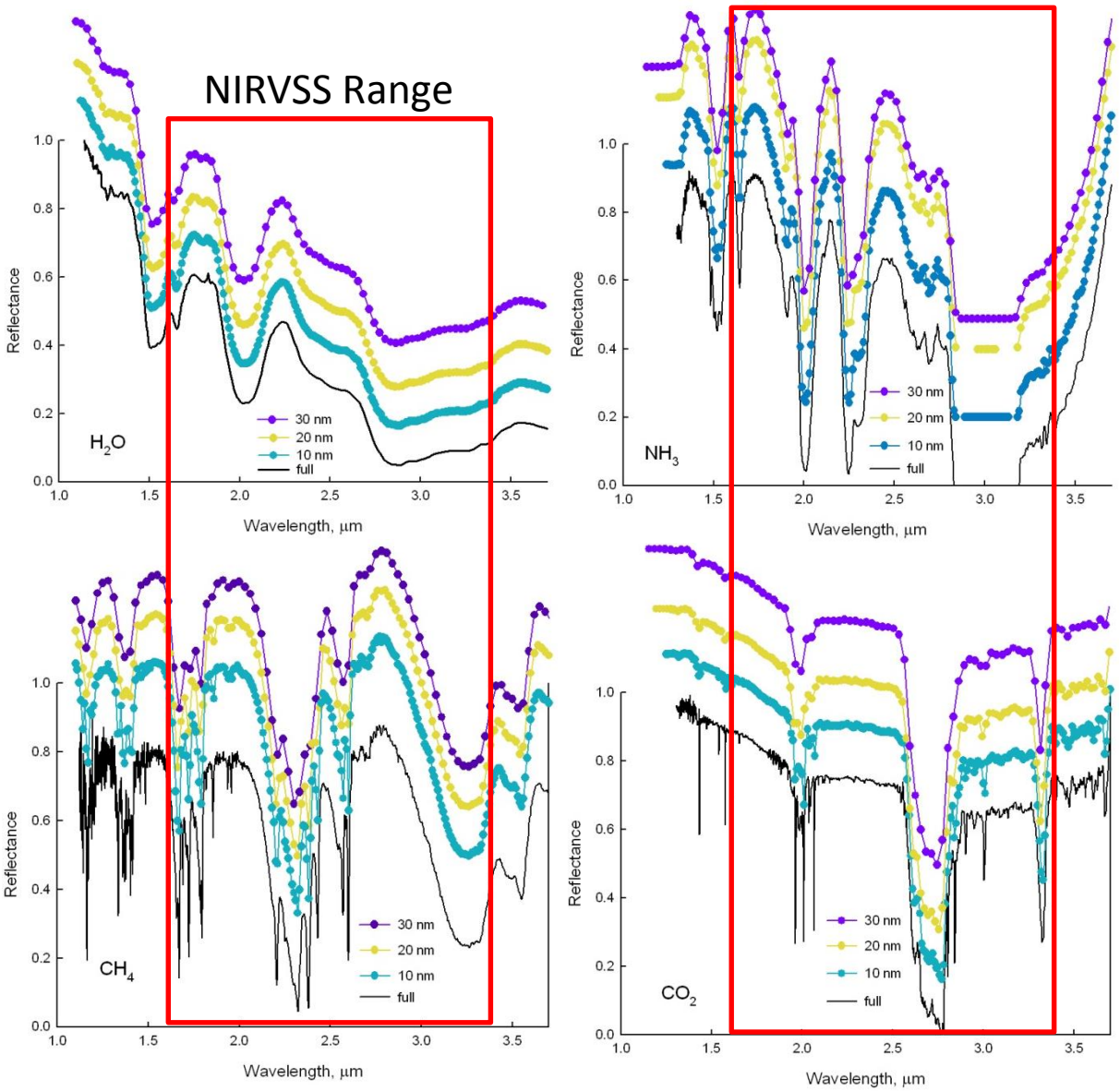
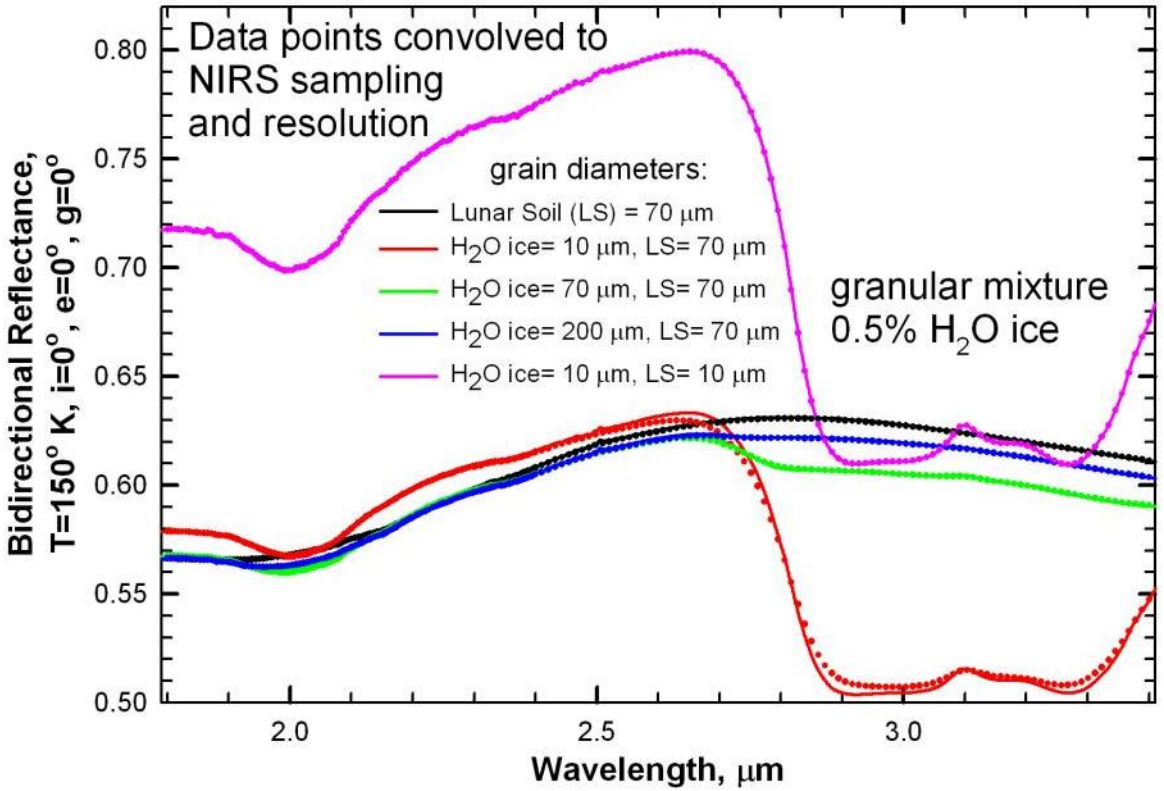


How Sensitive to H_2O Ice?



Ice (μm)	Soil (μm)	BD_{2000} (%)	SNR,3σ	BD_{3000} (%)	SNR, 3σ
10	10	5.0	49	20.1	14.5
10	70	4.0	75	19.4	15
70	70	3.5	86	2.7	111
200	70	2.9	103	0.6	500

NIRVSS - Science Goals

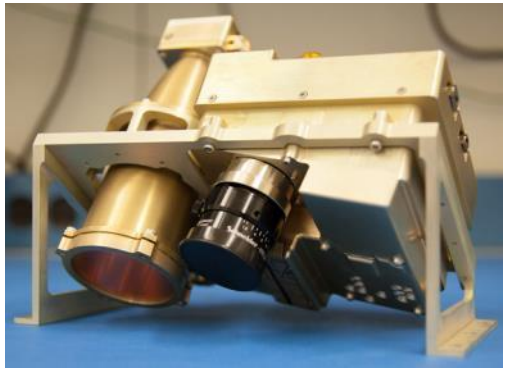
1. **Monitor** the surface during rover traverses and at excavation sites for water and other volatiles.
   - Identify surface bound H_2O/OH
   - Constrain mineralogical/geological context
   - Measure surface temperatures

2. **Observe** the immediate vicinity of the drill site before and during drill operations to look for near real-time changes in the properties of the exposed materials.
   - Identify volatiles, including water form (e.g., ice vs. bound)
   - Identify gasses evolved during drilling activity
   - Constrain the volatile presence in top ~20-30 cm of regolith: provides constraints on neutron measurements of H-abundance
   - Constrain surface/subsurface temperatures

NIR Volatiles Spectrometer System

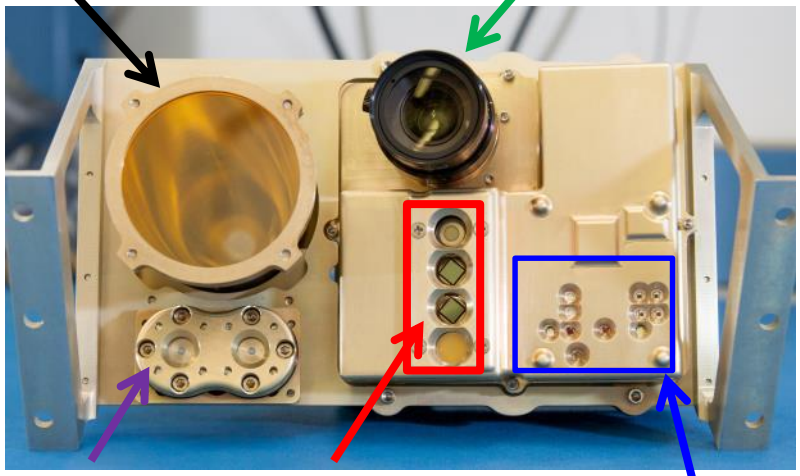
Spectrometer

Bracket Assembly



Lamp Assembly

Drill Ops Camera (DOC)



Fiber Optics to Spectrometers

LCS

LEDs

No ITAR/EAR expor

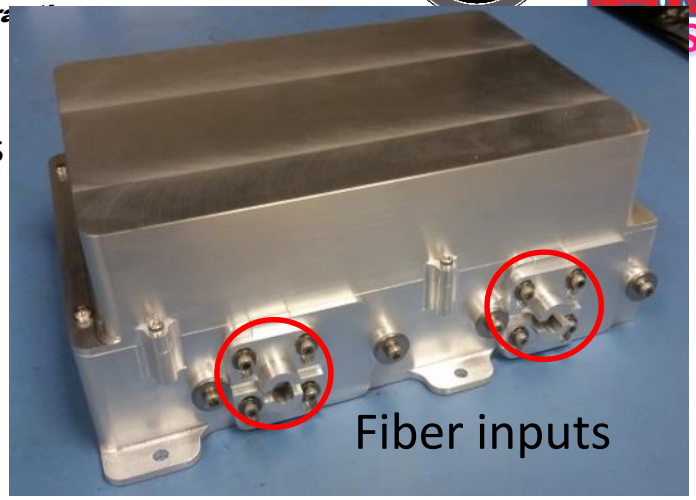
Key instrumental characteristics for NIRVSS, Bracket Assembly

Property	Spectrometer	NIRVSS Bracket Assembly		
	NIRVSS	Lamp	DOC	LCS
Size (mm)	202 x 154 x 82	204 x 130 x 151		
Mass (kg)	1.97	1.14		
Native Resolution	N/A	N/A	2048 x 2048	N/A
Image Scaling Options	N/A	N/A	2048 x 2048, 1024 x 1024, 512 x 512, 256 x 256, 128 x 128	N/A
Wavelength range, sampling, (mm)	1.6-2.4, 0.009 2.3-3.4, 0.012	N/A	410, 540, 640, 740, 905, 940, 1025 nm	8, 10.6, 14, 25
Power (W)		BA Electronics: 1.68 (n), 1.75 (p)		
Nominal (n): Peak (p):	6.8 7.4	12.3	0.3 (n) 1.0 (p), 7.14 (LED flash)	0.28
IFOV, (°)	≈24° each	≈26°	camera, 55° LEDs, 90-100°	≈35°
Thermal (°C) Survival: Operational:	 -25 >T > +75 -20 > T > +45	 -50 > T > +120 -20 > T > +110	 -30 > T > +70 -20 > T > +60	 -30 > T > +70 -20 > T > +60
Data Interface, rate (kbaud)	2 - RS-422, 115.2	NA	RS-422, 230.4	RS-422, 9.6
Input Voltage	28 +/- 6V	28 +/- 6V		

NIRVSS Components

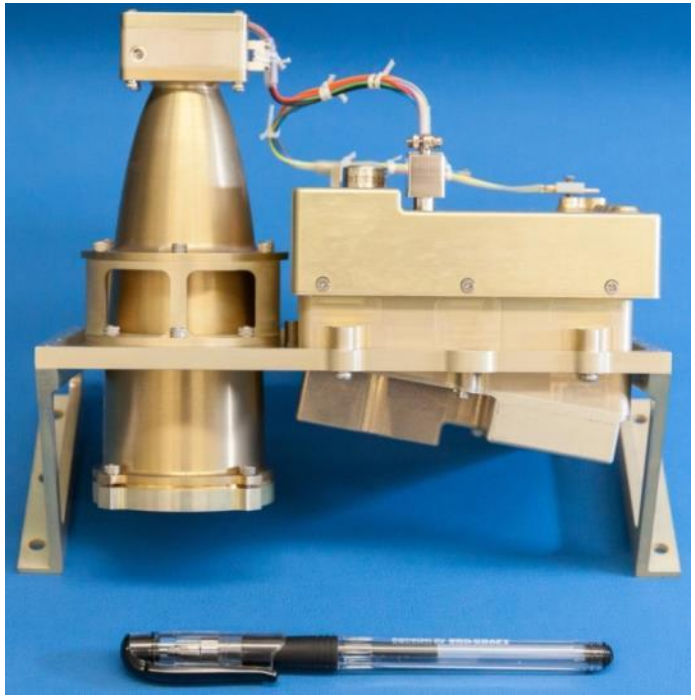
Spectrometer

- Sufficient wavelength range and resolution to identify key volatiles (solid and gas)
  - 2 optical Engines; ShortWave (SW) ≈1600-2400 nm and LongWave (LW) ≈2300-3400 nm
  - Spectral sampling SW ≈9 nm LW ≈12 nm
  - Full spectrum approximately every 0.7 sec
- Achieve SNR > 100 at 2 μm and 3 μm while roving and drilling



Bracket Assembly

- IR emitter
  - Enables observations while roving and drilling, in dark
  - Bright enough to meet SNR requirement while in shadow
- Drill Observation Camera (DOC)
  - Image drill area with sufficient FOV to observe cuttings
  - Sufficient resolution to identify 0.15 mm regolith structure
  - 8 LEDs for multi-spectral imaging
- Longwave Calibration Sensors (LCS)
  - thermal emission correction for 3 μm band; required for determining concentrations of OH/H2O
  - Measure radiance at 8, 10, 14 and 25 μm

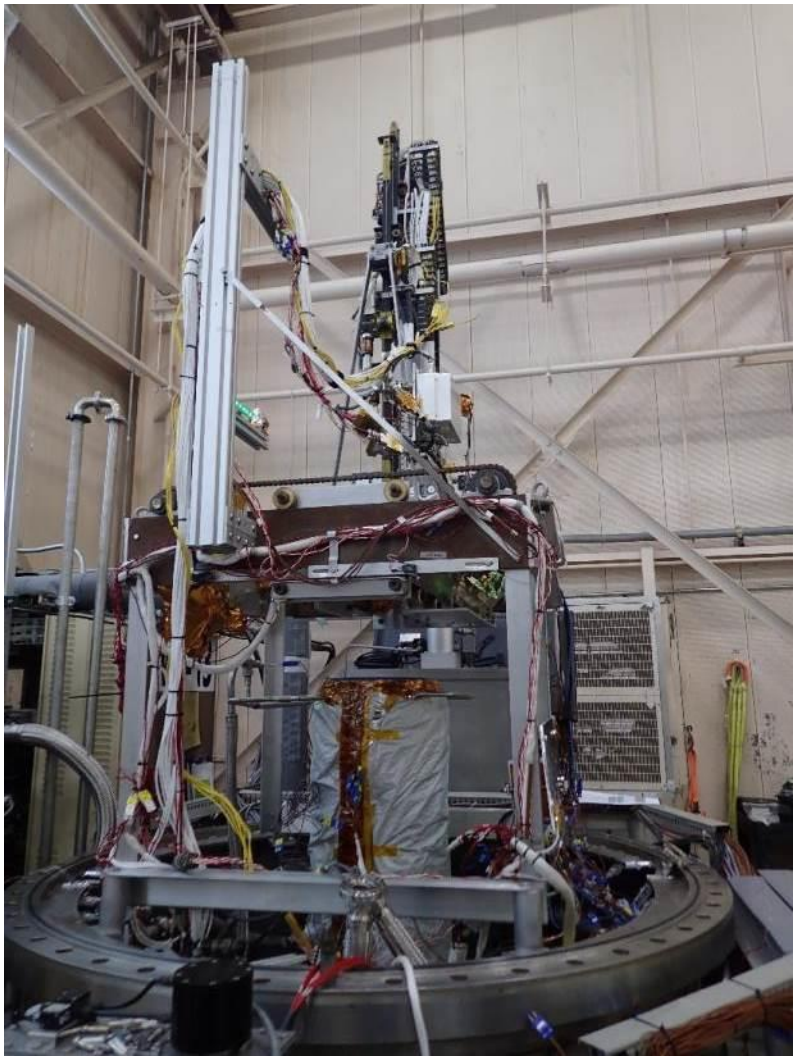


NIRVSS Testing

RESOLVE: Regolith & Environment Science and Oxygen & Lunar Volatile Extraction

RP15 Porotype rover with payload

RP15 Remote Ops at ARC



GRC VF13 TVAC Chamber

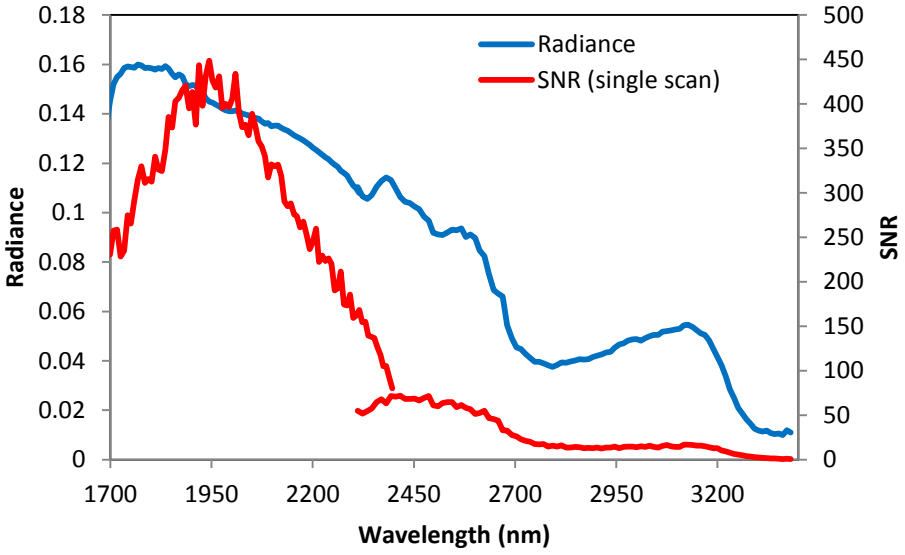
NIRVSS Testing

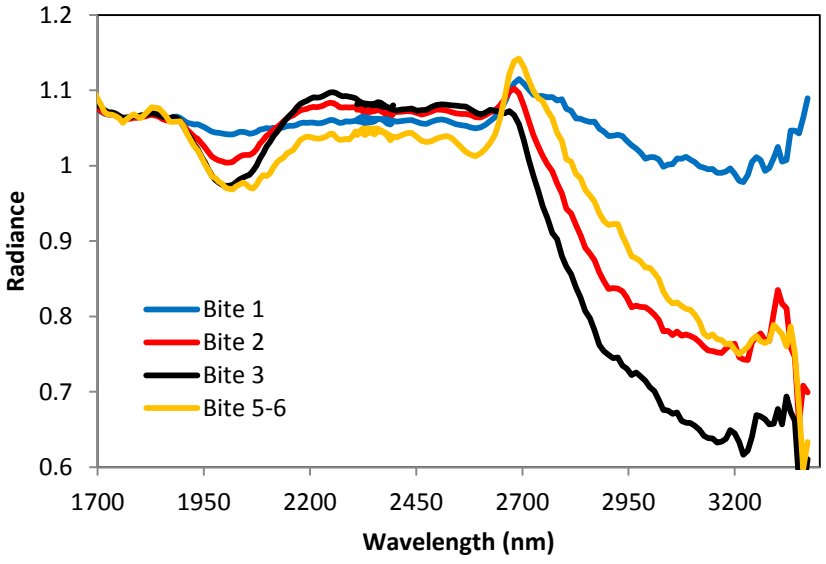
RP15 Rover Testing

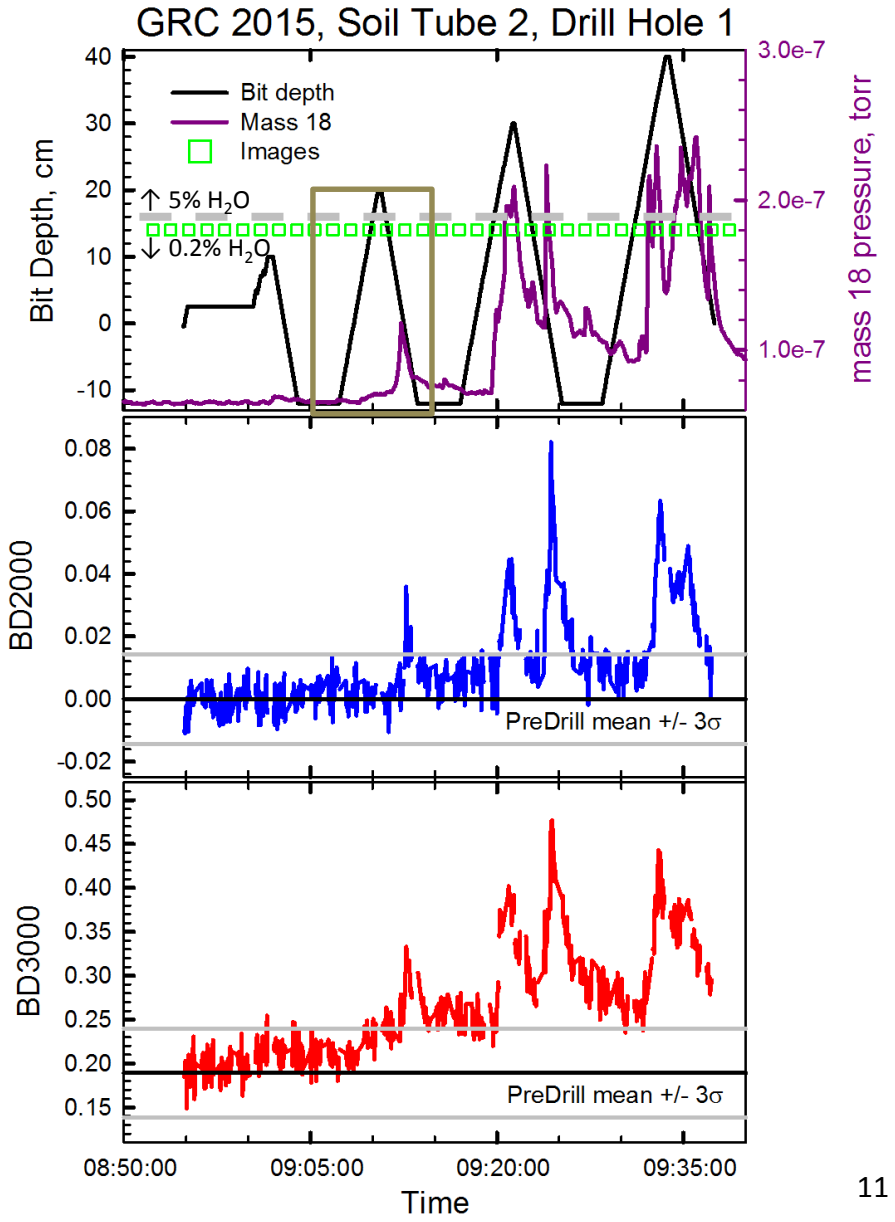
GRC TVAC Testing

NIRVSS – GRC Drilling Tests

RESOLVE: Regolith & Environment Science and Oxygen & Lunar Volatile Extraction







NIRVSS - Summary

- NIRVSS spectrometer & illumination source provide sensitivity to changes in soil water content while roving and as drilling progresses
  - ➢ Can provide a “quick” assay of drill cuttings for volatile content
- Relatively modest “footprint” at around 3kg and 15W
- NIRVSS DOC captures morphology and behavior during drilling and LEDs provide compositional recognition
- NIRVSS LCS designed for correction of surface T’s > 200° K, and can measure the scene temperatures between 80 to 400 K